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14. ABSTRACT In the ACT-R modeling approach we assume that in order to become skilled at a task, we start with knowledge that first consists of a set of memorized instructions that is interpreted by the cognitive system. This interpretation process is gradually internalized by a process we call production compilation, leading to improvements in performance in terms of speed and accuracy. The quality and robustness of the resulting skill partially depends on the representation of the initial instructions. We found that if these instructions are grounded in what is perceived in the world, the resulting performance is better in terms of speed and accuracy, but more importantly in terms of being able to deal with new and unexpected situations. The reason is that grounded instructions require less internal control, which reduces the computational complexity of the skill. Several studies with a simulated Boeing 777 Flight Management System have shown that participants who receive instructions grounded in perception perform much better than participants who receive classical checklist instructions.					
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In the ACT-R modeling approach we assume that in order to become skilled at a task, we start with knowledge that first consists of a set of memorized instructions that is interpreted by the cognitive system. This interpretation process is gradually internalized by a process we call production compilation, leading to improvements in performance in terms of speed and accuracy. The quality and robustness of the resulting skill partially depends on the representation of the initial instructions. We found that if these instructions are grounded in what is perceived in the world, the resulting performance is better in terms of speed and accuracy, but more importantly in terms of being able to deal with new and unexpected situations. The reason is that grounded instructions require less internal control, which reduces the computational complexity of the skill. Several studies with a simulated Boeing 777 Flight Management System have shown that participants who receive instructions grounded in perception perform much better than participants who receive classical checklist instructions.

We explored a number of extensions to the Boeing 777 Flight Management Task experiment and cognitive model. In addition, we performed a number of studies that focused on cognitive control in general.

We performed three new experiments with the FMS task:

- In a first experiment we collected eye-movement data to assess the visual information subjects used to decide on their actions. This experiment showed that subjects extensively rely on visual information to guide their actions.
- In a second experiment we compared subjects who had received no procedural task instructions at all to subjects who did receive instructions. Although performance by the non-instructed subjects was poor initially, they reached the same performance levels as the instructed subjects after approximately 15 problems.
- In a third experiment we introduced equipment malfunctions of two different types. One type introduces display malfunctions, making it harder to assess the state of the system. The second type concerns state malfunctions, in which correct actions may put the system in a wrong state. The results of this experiment showed that subjects that received the grounded instructions outperformed the subjects that received the checklist instructions, but particularly on the problems in which there was a display malfunction. The trials of the second type of malfunction, the state malfunctions, turned out to be too easy to produce a difference compared to trials without malfunction.

We successfully modeled the first experiment by extending the visual module of the ACT-R architecture with a means to keep track of locations on the screen, and a system

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to learn from instructions called ACT-R/Lisa. The model was not only able to fit the performance data, but also to predict the details of the eye-movements.

To broaden our investigation of the role of control in task performance, we looked at control in smaller tasks on two different levels: procedural and declarative. At the declarative level it is necessary to keep previous goals from interfering with the current one. In that context we used results from a set of Stroop experiments as a guide to set up activation system that suppresses the activation of completed goals. At the procedural level we concluded from a model of the attentional blink that changes in control state are mediated through separate cognitive actions, and that interference at the procedural level can therefore impact the maintenance of control in a task.

Archival publications during reporting period:

Juvina, I. & Taatgen, N.A. (2009). A repetition-suppression account of between-trial effects in the Stroop task. *Acta Psychologica*, 131, 72-84.

Taatgen, N.A., Juvina, I., Schipper, M., Borst, J., & Martens, S. (2009). Too much control can hurt: A threaded cognition model of the attentional blink. *Cognitive Psychology*, 59(1), 1-29.

Taatgen, N. A., Huss, D., Dickison, D. & Anderson, J. R. (2008). The acquisition of robust and flexible cognitive skills. *Journal of Experimental Psychology: General*, 137(3), 548-565.

New discoveries, inventions or patent disclosures: None